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Revisiting Abell 2744: a powerful synergy of *GLASS* spectroscopy and *HFF* photometry.

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Abstract. We present new emission line identifications and improve the lensing reconstruction of the mass distribution of galaxy cluster Abell 2744 using the Grism Lens-Amplified Survey from Space (*GLASS*) spectroscopy and the Hubble Frontier Fields (*HFF*) imaging. We performed blind and targeted searches for faint line emitters on all objects, including the arc sample, within the field of view (FoV) of *GLASS* prime pointings. We report 55 high quality spectroscopic redshifts, 5 of which are for arc images. We also present an extensive analysis based on the *HFF* photometry, measuring the colors and photometric redshifts of all objects within the FoV, and comparing the spectroscopic and photometric redshift estimates. In order to improve the lens model of Abell 2744, we develop a rigorous algorithm to screen arc images, based on their colors and morphology, and selecting the most reliable ones to use. As a result, 25 systems (corresponding to 72 images) pass the screening process and are used to reconstruct the gravitational potential of the cluster pixellated on an adaptive mesh. The resulting total mass distribution is compared with a stellar mass map obtained from the *Spitzer* Frontier Fields data in order to study the relative distribution of stars and dark matter in the cluster.

Keywords. galaxies: clusters: individual (Abell 2744), galaxies: evolution, line: identification

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Taking advantage of both the grism slitless spectroscopy from the Grism Lens-Amplified Survey from Space (*GLASS*, P.I. Treu), and the deep 7-filter imaging from the Hubble Frontier Fields (*HFF*) initiative (P.I. Lotz), this work (Wang *et al.* 2015) is focused on presenting new emission line identifications in the center of Abell 2744, i.e., the first cluster with both data sets available, and improving its mass model through our carefully devised systematic screening mechanism. For a more general understanding of the observing strategies and other early results from *GLASS*, please refer to Schmidt *et al.* (2014); Jones *et al.* (2015); Treu *et al.* (2015); Vulcani *et al.* (2015) and proceedings for *FM22.2.02*, *FM22.2.03*, and *FM22.4.03*.

1. *GLASS* observations of the Abell 2744 center

As shown in Fig. 1, the *GLASS* prime pointings of Abell 2744 are split into two position angles (P.A.s) nearly 90° apart, to facilitate disentangling contaminations from neighboring objects. The specific exposure times of all WFC3 filters and grisms used by *GLASS* are given in Tab. 1.

- **The targeted search**. We conducted a line emitter search dedicated to all proposed multiple image candidates, which has a total number of 179.

P.A. (deg)	G102 (sec)	F105W (sec)	G141 (sec)	F140W (sec)
135	10929	1068	4212	1423
233	10929	1068	4312	1423

Table 1. Exposure times of *GLASS* WFC3 grisms and imaging filters

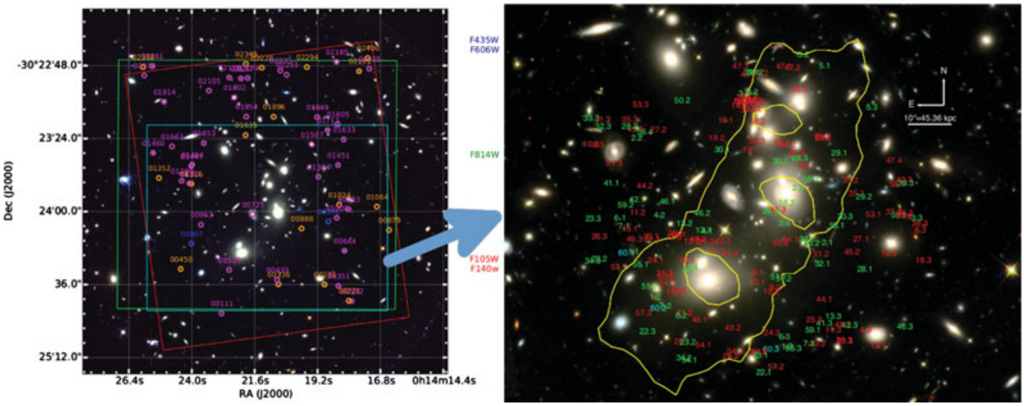

Figure 1. Left. We identified 37, 18, and 20 faint line emitters in *GLASS* data at $z_{\rm spec}$ quality level of secure (magenta), probable (orange), and possible (blue), respectively, among which 3, 2, and 2 individuals are multiply lensed. For the sake of clarity, only the two multiply imaged quality possible objects are shown. The red and green boxes denote the two nearly orthogonal spectroscopic pointings with P.A.=233° and P.A.=135°, respectively. **Right.** A zoom-in on the cyan squared region in the left panel, where the total mass distribution of Abell 2744 is modeled using our non-parametric prescription combining both strong and weak lensing signals. The true novelty of our work compared with previous cluster modeling efforts is that we deploy a systematic screening process on multiple arc systems and images, based upon the synthesized information from their colors, morphology and spectroscopy. As a result, out of the entire 57/179 arc systems/images prior to the screening, 25/72 systems/images passed (shown in green), while more than half did not (in red). The yellow contours are the critical curves at $z = 9$.

- **The blind search**. We also searched the spectra of all objects within the field of view of prime pointings blindly for potential emission line features.

As a consequence, we obtained 55 high quality (secure+probable) spectroscopic redshifts ($z_{\rm spec}$, see Fig. 1 for their locations), and estimated photometric redshifts ($z_{\rm phot}$) for the same ensemble of sources based upon the full-depth 7-filter *HFF* imaging using the `EAZY` code. It is found out that 25/55 of these sources have compatible $z_{\rm spec}$ and $z_{\rm phot}$ estimates at 1-σ confidence level. But note that catastrophic outliers do exist.

2. Improving the cluster lens model via screening the arc sample

Abell 2744 has remained one of the most extensively studied massive clusters. Especially with the arrival of the *HFF* data, the number of proposed strongly lensed systems has dramatically increased. However, even after our spectral line inspection efforts, there are merely 7 systems which have secure z, i.e., $z_{\rm spec}$. A reasonable argument is that some false-positives must be present in the proposed arc sample, given the comparison between $z_{\rm spec}$ and $z_{\rm phot}$ that we have shown. For the first time, we therefore bring forward a systematic screening process to purify the arc sample.

First of all, We measure 4 colors on each arc image from the 7 *HFF* filters and calculate color-χ^2 values. Secondly, we eyebal all arc images and assign morphology scores to them. We also take into account whether the source is contaminated, as well as the Bayesian redshift for the arc system is usable. After this screening, more than half in the original proposed arc candidate sample are excluded, and thus we improved our modeling due to the enhanced purity of our arc sample that is fed to the modeling machinery.

We also use the *Spitzer* Frontier Fields data to measure a map of stellar mass surface density, and thus can obtain a map of stellar-to-total-mass ratio. It is found out that the ratio varies significantly across the cluster field, ranging from 0 to 5%, tentatively inferring that stellar mass does not trace total mass in this interacting system.

References

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